

System Design and Project Plan

PEZ (Pills EZ) Dispenser

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System Design

System Design

PEZ (Pills EZ) Dispenser

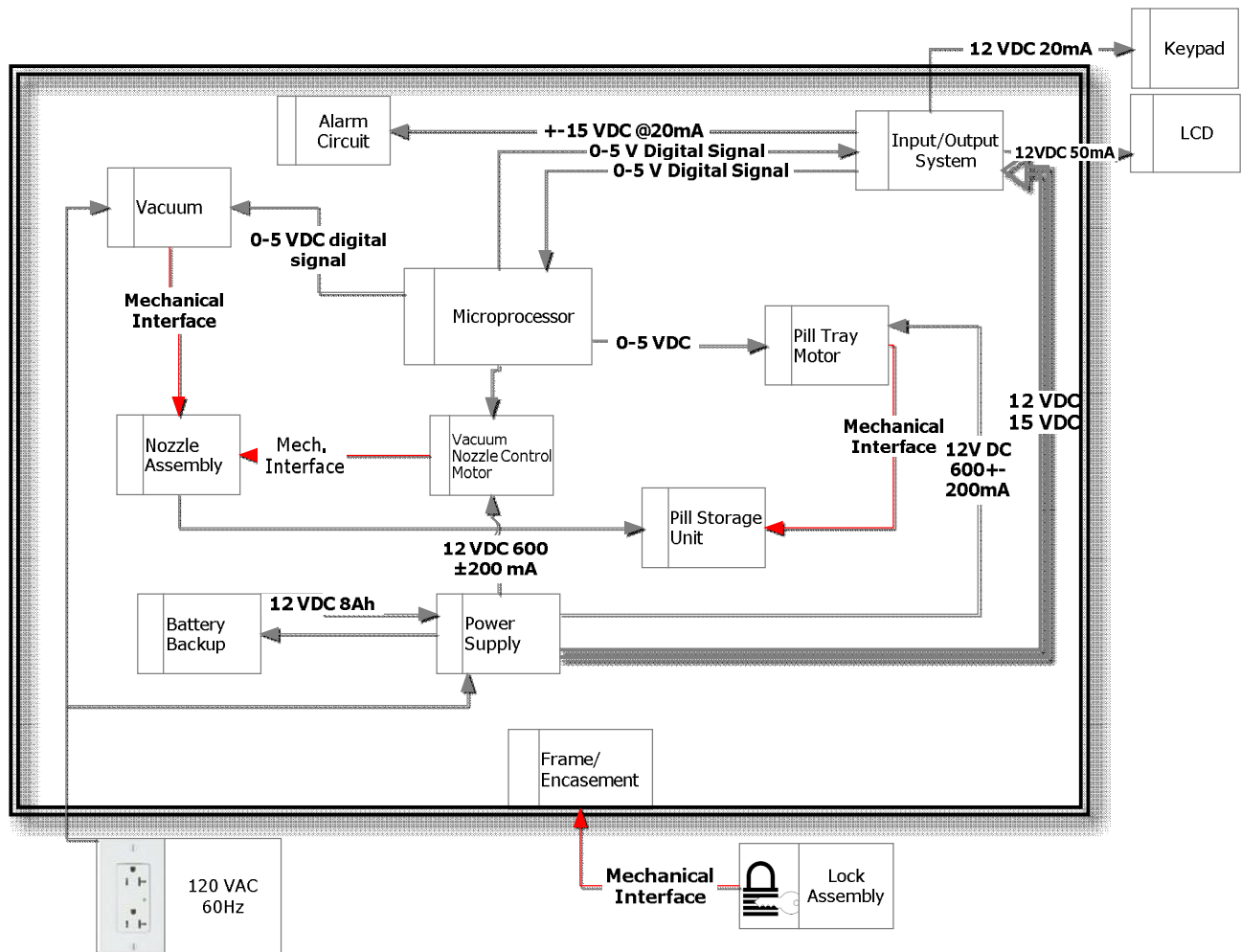
Background

Presently, many people are dependent upon medications in their daily lives. An increasing number, especially the elderly, are required to take multiple different types of medications of varying dosages at different times throughout the day. This can become a complicated procedure for anyone, causing missed doses, incorrect doses, and potentially life threatening mistakes. Medication works best when taken on a routine schedule at the proper dosage. Although, medicine dispensing machines that can solve these problems currently exist, they can range upwards of twelve hundred dollars. Clearly, the average household cannot afford this indispensable luxury. Based on this situation, a user friendly, affordable, semi-compact device to dispense medicine at home will be developed.

System Overview

The PEZ Dispenser prototype will attempt to simplify the medication dosing process for the average customer. The correct dosage of medication will be dispensed throughout the day based on user determined specifications entered via keypad. The user will be prompted to take medications throughout the day by an alarm with an audible range similar to that of an average bedside alarm clock. The interior of the dispenser, which can be accessed upon unlocking the lid, will hold a circular, rotating tray on which will be eleven individual containers. It has been determined through research¹ that the average individual takes no more than ten different types of medication. Therefore, up to ten of these containers can be filled by the user with the desired medication. The eleventh container will be used to dispense medication. The correct amount of medication will be obtained through a vacuum system by which individual pills will be lifted from their containers and transported to the dispensing container. The central processing unit, or the microprocessor, will store all information needed to display a clock, sound an alarm, and dispense a dose of medication. The dispenser will be powered by a standard 120V AC, 60Hz power supply. In case of emergency, the dispenser will be equipped with a back-up battery which will provide at least 12 hours of reserve power.

Block Diagram



Functional Description of Blocks

Power Supply

The power supply system receives 110 VAC from a wall outlet. It then steps down the voltage and current to the correct magnitude for each of the subsystems.

Input:	110 VAC, 60Hz Grounded
Output:	To microprocessor Ĩ 5 VDC at 300 mA To alarm Ĩ ± 15 VDC at 20 mA To keypad Ĩ 12 VDC at 20mA To LCD Ĩ 12 VDC at 50mA To pill tray motor Ĩ 12 VDC at 600 mA $\pm$ 200 mA To vacuum nozzle control motor Ĩ 12 VDC at 600 mA $\pm$ 200 mA To vacuum Ĩ 110 VAC, 60Hz (direct from wall)

Microprocessor

The microprocessor will store all information needed to display a clock, sound an alarm, and dispense a dose of medication. The microprocessor will interface with an alpha/numeric keypad, LCD (Liquid Crystal Display), alarm components, vacuum circuitry, and the motor control circuitry. A user will be able enter all information needed via the keypad. The clock display and all prompted information needed from program will be displayed via LCD. The appropriate signals will be sent to control the motors motions. Also, the vacuum control circuitry will be sent a five volt digital signal to activate the vacuum.

Input:	Power 5V DC at max of 300 mA Digital signals from Keypad 0 to 5V at 0 to 20mA
Output:	Digital signal to alarm circuitry Ĩ 0 to 5V DC at 0 to 25 mA Digital signal to LCD Ĩ 0 to 5V DC at 0 to 25 mA Digital signal to keypad Ĩ 0 to 5V DC at 0 to 25 mA Digital signal to vacuum Ĩ 0 to 5V DC at 0 to 25 mA Digital signal to motor control circuit Ĩ 0 to 5V DC at 0 to 25 mA

Input/Output System:

LCD

The user will be able to view any stored data pertaining to the alarms set, medications stored, and dosages entered. The LCD will display the current time along with a number of messages to the user. These messages include things such as, setting a user pin, questions about entering new medication data, prompting visually when medication is ready for removal, and setting the clock.

Input:	Power 0 to 5V DC at max of 200mA Digital Signals from Microprocessor 0 to 5V DC at 0 to 25mA
Output:	Text to viewing area.

Keypad

When prompted, or if the user needs to interact with PEZ, the user will enter information via keypad. The keypad will be alpha/numeric and send all digital signals to the microprocessor for decoding and storage.

Input:	Power 0 to 5V DC at max of 20mA Digital Signals from Microprocessor 0 to 5V DC at 0 to 25mA
Output:	Digital signals to microprocessor 0 to 5V at 0 to 20mA

Alarm

The alarm will sound indicating a dose is scheduled to be taken. The alarm will be audible at a minimum of 80 dB and a tone of approximately 1000 Hz.

Input:	Power 0 to 12V DC at 50mA
Output:	> 80 dB Tone

Pill Tray/Motor

The pill tray will contain the user's pill prescriptions. It will hold up to ten different pill types, and it will be capable of holding up to 90 1.0 gram pills. A motor having an output torque in the range of 0.15-0.3 N-m will be sufficient to rotate the tray. The motor will rotate the tray through the necessary angle so that the prescribed pill's bin will be located on the suction nozzle assembly's axis of translation.

Input:	12 VDC at 600 mA $\pm$ 200 mA
Output:	Correct pill bin is positioned on the nozzle assembly's axis of translation.

Vacuum

The vacuum will provide enough suction to lift and hold pills of various masses, ranging from 10 mg to 1.0 g. The necessary force provided by the vacuum, therefore, is equivalent to the force needed to overcome the force of gravity on a 1.0 g pill, 0.00981 N.

Input:	110 VAC, 60Hz
Output:	Suction

Nozzle Assembly/Motor

The nozzle assembly will translate the suction tip of the vacuum hose into the pill bin directly below it, allowing it to make contact with each pill and affix to it. The nozzle will be selected such that small pills or pieces of pills cannot be sucked inside. The torque requirements for the motor to drive the assembly have yet to be determined.

Input:	12 VDC at 600 mA $\pm$ 200 mA
Output:	Vertical translation of the vacuum's nozzle

Frame/Encasement

The encasement will provide protection for the components of the dispenser, and the frame will provide sufficient strength to support the system and allow for transportation. The encasement will have a locking door which will allow access to the pill tray in the event that power cannot be supplied. The dimensions will be in the range of 41 cm x 41 cm x 41 cm (16 in x 16 in x 16 in) to 77 cm x 77 cm x 77 cm (30 in x 30 in x 30 in).

Input:	None
Output:	None



Project Plan

Organization and Management

Our team consists of two mechanical engineering students, two electrical engineering students, and a computer engineering student. Project management and design tasks will be broken down into the following responsibilities:

- **Kyle Smith** (Electrical Engineer)

Kyle is the project manager and responsible for the project being completed on time and under budget. He will ensure the required documents and presentations assigned are completed and turned in on time. He is responsible for design and construction related to the alarm circuit and backup battery system.

- **Ben Anderson** (Mechanical Engineer)

Ben will be in charge of the proper selection and modification of the vacuum assembly as well as a backup for Matt on the frame, pill tray, and nozzle assembly.

- **Matt Strasser** (Mechanical Engineer)

Matt will be in charge of the design and construction of the frame, pill tray, and nozzle assembly. He will also act as a backup for Ben on the remaining mechanical processes in the project.

- **Jason Terhune** (Computer Engineer)

Jason will be responsible for the microprocessor and the user interface for the device, which includes an LCD and a keypad. He will also design and order a PCB to act as a hub for all devices controlled by the microprocessor.

- **Yao “Annie” Yao** (Electrical Engineer)

Annie will be responsible for the power supply design and construction as well as being a backup for Jason on the user interface and microprocessor.

Each engineer is responsible for the completion of the individual tasks to which they have been assigned, however, it is important to note that work done on each task is not exclusive to the engineers listed. Every member of the team will be expected to be familiar with each other's systems and to keep their ultimate integration in mind at all times during the design process.

Work Breakdown Structure (Fall)

ID	Task Name	Description	Deliverables/Checkpoints	Duration	People
F 1.0	Project Selection	Make a final decision on which project to pursue	Project confirmation	8/30-9/7	All
F 2.0	Preliminary System Design	Basic design of what system will do	Choose best solutions and apply them	9/7-9/28	All
F 3.0	Requirements Specification	Document that sets the quantitative requirements for the project	Written document	9/10-9/28	All
F 4.0	System Design and Project Plan	Breakdown of design and build process and detailed scheduling	Written document and formal presentation	9/28-10/14	All
F 4.1	Report	Write detailed report regarding the above ideas	Written document	9/28-10/12	All
F 4.2	Presentation	Present the ideas to faculty	PowerPoint and verbal presentation	10/8-10/14	All
F 5.0	Mechanical Systems Design	Detailed design of each mechanical subsystem	SolidWorks models, analysis, data sheets, calculations, etc.	9/28-11/5	Ben, Matt
F 5.1	Pill Tray Assembly/Motor	Holds pills and uses motor to rotate tray	SolidWorks model, analysis, calculations, and motor data sheet	9/28-10/19	Matt, Ben
F 5.2	Vacuum System	Retrieves pills from chambers	Calculations and testing	10/1-10/15	Ben, Matt
F 5.3	Vacuum Nozzle Assembly/Motor	Translates vertically to retrieve pills from chambers	SolidWorks model, analysis, calculations, and motor data sheet	10/5-10/26	Matt, Ben
F 5.4	Frame Design	Encapsulates all components of the project	SolidWorks model and dimension calculations	10/26-11/5	Matt, Ben
F 6.0	Microprocessor Selection	Microprocessor selection and mounting solutions	Electrical schematic, analysis, and data sheets	10/6-10/11	Jason, Kyle
F 7.0	Power Supply Selection	Provides power from the wall to all subcomponents of the system	Electrical schematic, analysis, and calculations	9/28-10/19	Annie, Kyle
F 8.0	Battery Backup System Design	Provides a 12-hour alternate power supply when wall power is unavailable	Electrical schematic, analysis, and calculations	10/12-10/26	Kyle, Annie
F 8.1	Estimate Power Consumption	Estimate power draw from all sub-components	Power consumption calculations	10/12-10/26	Kyle, Annie
F 8.2	Select Battery Chemistry	Research best choice for battery chemistry to meet power consumption and size requirements	Analysis, data sheets, and part selection	10/12-10/26	Kyle, Annie
F 9.0	I/O System Design	Allows user to input, view pill information, and set alarms	Electrical schematic, analysis, and data sheets	10/13-11/8	Jason, Annie
F 9.1	LCD Screen	Displays vital information to the user(s)	Electrical schematic, analysis, and data sheets	10/13-10/22	Jason, Annie
F 9.2	Keypad	Allows the user(s) to input information	Electrical schematic, analysis, and data sheets	10/15-11/8	Jason, Kyle
F 9.3	Alarm System	Audibly alerts the user(s) when it is time for a dose	Electrical schematic, analysis, and data sheets	10/13-11/8	Kyle, Annie
F 10.0	System Analysis	Ensure that individual parts will integrate into the system as a whole	Finalized system design	11/9-12/6	All
F 11.0	Final Design	Final system and sub-function design	Written document and presentation	11/15-12/9	All
F 11.1	Report/Presentation	Write detailed report regarding the above ideas and present ideas to faculty	Written document and formal presentation	11/9-12/9	All
F 11.2	Build Mock-up	Build a non-functioning physical representation of the system	Fully-assembled structure representing each sub-system	11/9-12/9	All
F 12.0	Documentation	Keep records of all design work, research, and tests	Documents and engineering notebooks	8/30-12/9	All
F 13.0	Project Management	Supervise the completion of project goals on time and within budget	Deadlines, constraints, and specifications met	8/30-12/9	Kyle

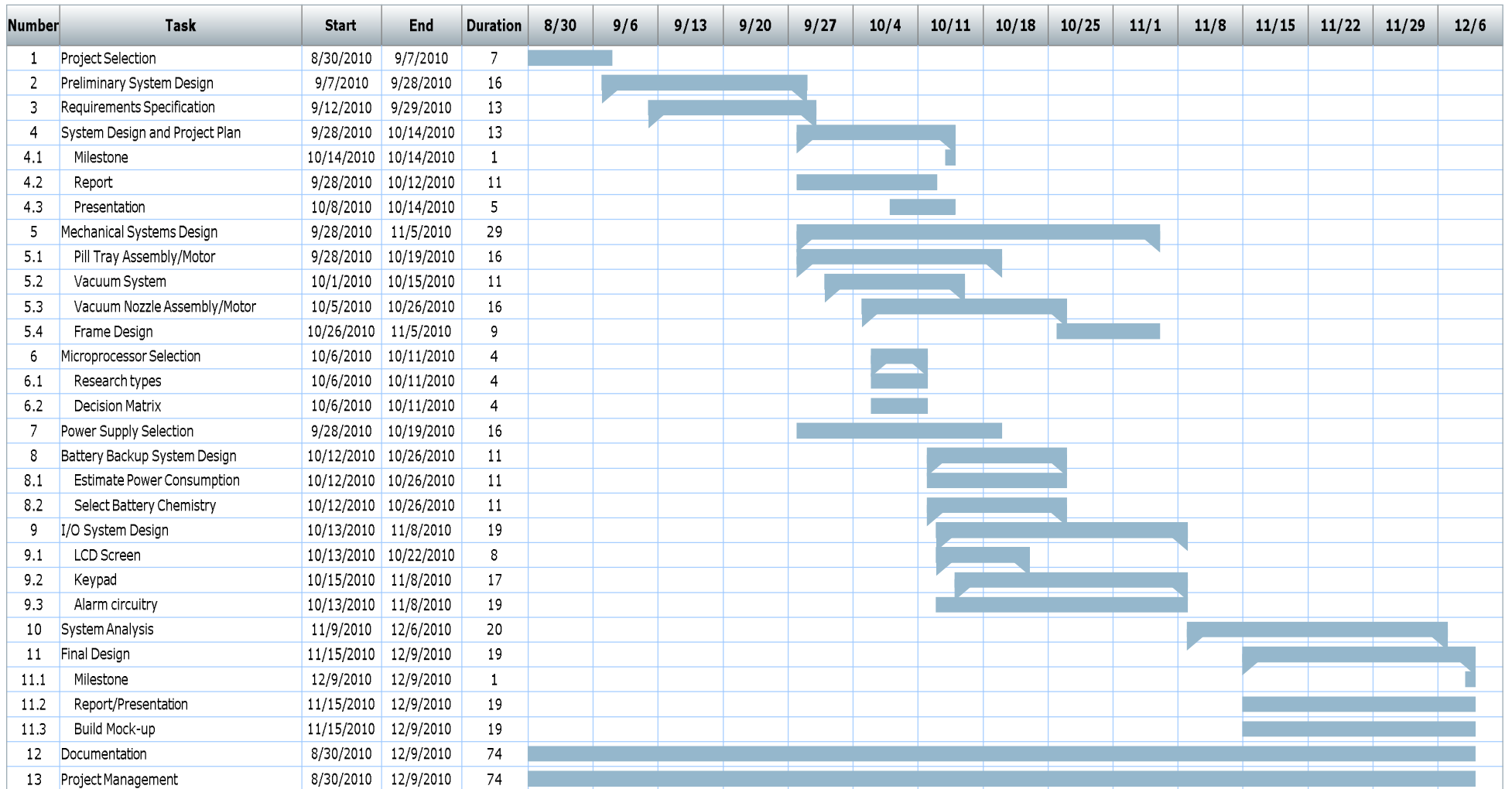
Work Breakdown Structure (Spring)

ID	Task Name	Description	Deliverables/Checkpoints	Duration	People
S 1.0	Parts Assembly and Testing	Assemble all parts and verify that they work correctly	Working modules and test data	1/20-4/25	All
S 1.1	Pill Tray and Motor	Build, assemble, and test rotation of the tray	Functioning system of tray and motor assembly	1/20-2/1	Matt, Ben
S 1.2	Vacuum System	Test system using required range of pill types and attach to nozzle assembly	Functioning vacuum pill-retrieval system	2/1-2/15	Ben, Matt
S 1.3	Vacuum Nozzle and Motor	Build, assemble, and test vertical translation	Functioning system of vacuum nozzle, gear, and rack	2/15-3/1	Ben, Matt
S 1.4	Power Supply	Implement and test voltage control circuit	Working module that steps down the voltage and current to the correct values	1/20-2/1	Annie, Kyle
S 1.5	Backup Battery System	Build and test that the battery will power system for 12 hours	Functioning battery system	2/1-2/8	Kyle, Annie
S 1.6	I/O System Implementation	System through which the user interfaces with the prototype	All components built and functioning to specifications	2/10-3/11	Jason, Kyle, Annie
S 1.6.1	LCD Screen	Connect and test LCD screen with the microcontroller	Working LCD screen that outputs all text correctly at the appropriate time	2/22-3/11	Jason, Annie
S 1.6.2	Keypad	Create and test a keypad circuit for user input	Working keypad that can be used to input information	2/22-3/8	Jason, Kyle
S 1.6.3	Alarm System	Build and test that alarm sounds at programmed times	Functioning, fully-audible alarm	2/10-2/18	Kyle, Annie
S 1.7	User Interface Configuration	Configure the keypad and LCD to work with programming	Working user interface	2/22-3/11	Jason, Annie
S 1.8	Board Etching	Design circuit boards for final system and etch them	Professional and self-made circuit boards	4/11-4/25	Kyle, Annie
S 2.0	Programming	Write and test code for microcontroller	Functioning system code	1/20-3/11	Jason
S 3.0	Project Status	Description of current progress of the project	Report and presentation	2/15-3/10	All
S 3.1	Report	Write detailed report regarding the above ideas	Written report	2/15-3/8	All
S 3.2	Presentation	Present the ideas to the faculty	PowerPoint and verbal presentation	3/8-3/10	All
S 4.0	System Frame Assembly	Build frame to house all sub-components	Completed frame	3/22-4/8	Matt, Ben
S 5.0	System Integration	Compile all modules to create prototype	Assembled project and test data	3/22-4/11	All
S 6.0	System Testing	Run full system test	Test data	4/11-4/25	All
S 7.0	Finalize Prototype	Verify correct operation and prepare for presentation	Completed prototype	4/25-5/3	All
S 8.0	User's Manual	Describes how to use the device and any special considerations	Document	4/12-4/30	All
S 9.0	Final Project	Final design and functioning prototype	Report and presentation	4/5-5/5	All
S 9.1	Report	Write detailed report regarding the above ideas	Written report	4/5-5/3	All
S 9.2	Presentation	Present project to faculty	PowerPoint, verbal presentation, and demonstration	5/3-5/5	All
S 10.0	Documentation	Keep records of all design work, research, and tests	Documents and engineering notebooks	1/18-5/5	All
S 11.0	Project Management	Supervise the completion of project goals on time and within budget	Deadlines, constraints, and specifications met	1/18-5/5	Kyle

Budget

Estimated Costs			
Item	Prospective Vender	Cost (\$)	Estimate Date
Motor (to rotate tray)	www.robotshop.com	38.00	Oct.4,2010
Tray	www.rexart.com	2.00	Oct.4,2010
Motor (for nozzle assembly)	www.robotshop.com	20.00	Oct.4,2010
Gear and Rack	www.qtcgears.com	100.00	Oct.4,2010
Vacuum	www.virtual-ii.com	90.00	Oct.4,2010
Plexiglas (40 x 80)	www.professionalplastics.com	150.00	Oct.4,2010
tools/building materials (for frame and enclosure)	<i>Lowe's</i>	75.00	Oct.4,2010
Microprocessor (PIC30F)	www.microchipdirect.com	10.00	Oct.4,2010
LCD	www.robotshop.com	17.95	Oct.4,2010
Keypad	www.jameco.com	21.95	Oct.4,2010
Battery	www.all-battery.com	35.00	Oct.4,2010
Power Supply	www.amazon.com/spytown.com	30.00	Oct.4,2010
Alarm	www.amazon.com	10.00	Oct.4,2010
PCB (manufactured and self-made)	www.PCBexpress.com	75.00	Oct.4,2010
Total		674.90	
Contingency		325.10	
Budget		1,000.00	

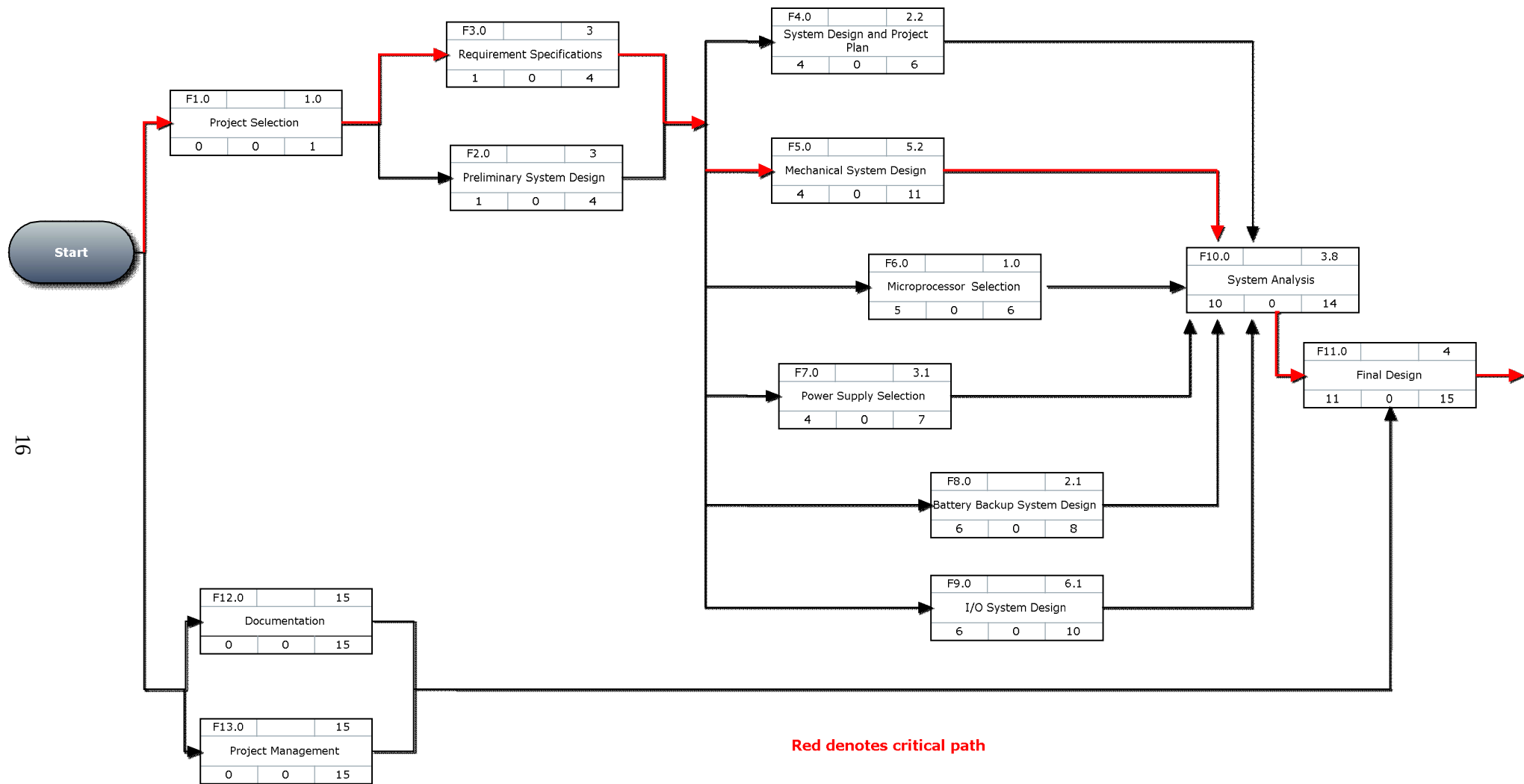
Fall Gantt Chart



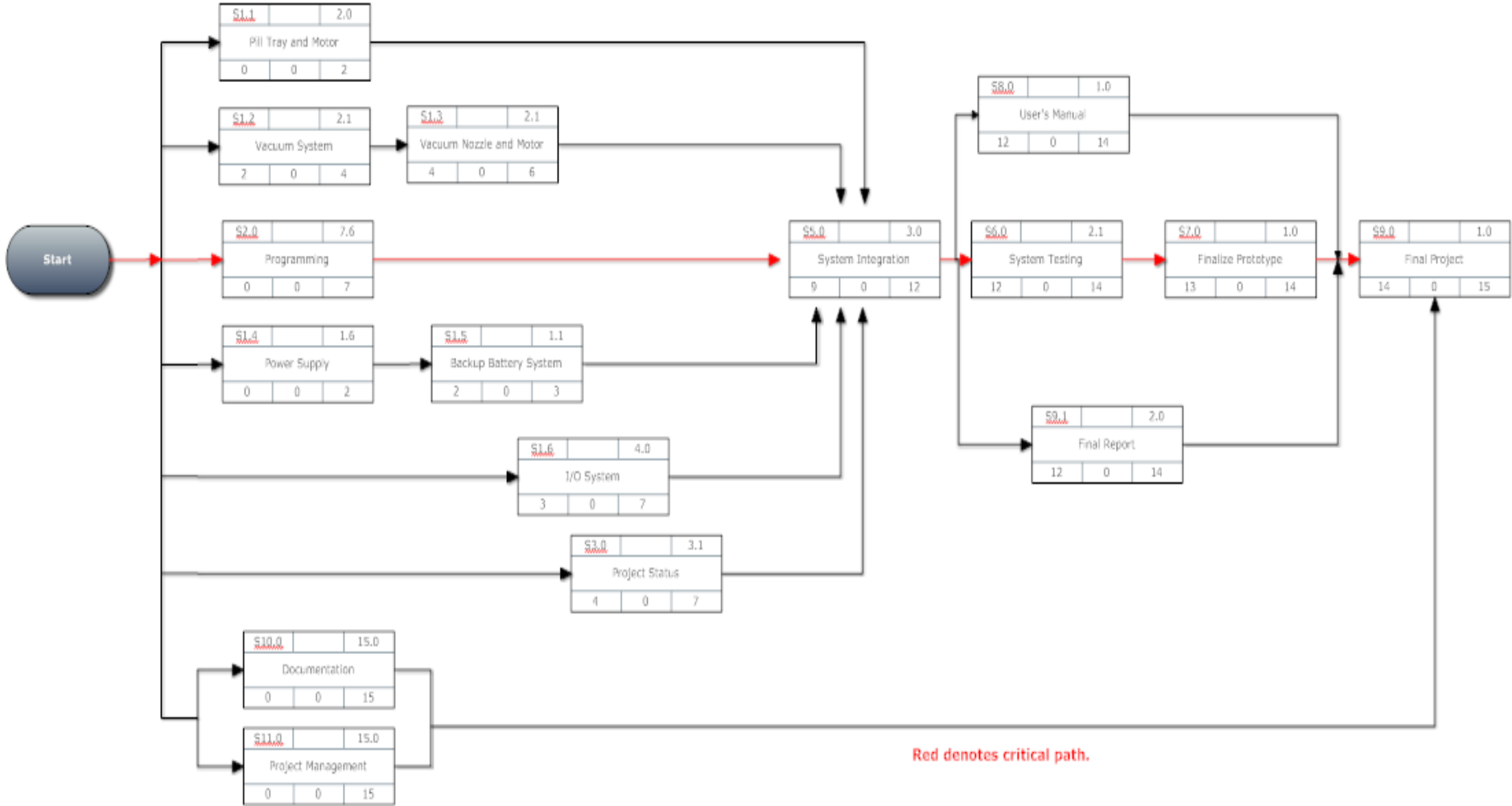
Spring Gantt Chart

Number	Task	Start	End	Duration	1/17	1/24	1/31	2/7	2/14	2/21	2/28	3/7	3/14	3/21	3/28	4/4	4/11	4/18	4/25	5/2	
1	Parts Assembly and Testing	1/20/2011	4/25/2011	68																	
1.1	Pill Tray and Motor	1/20/2011	2/1/2011	9																	
1.2	Vacuum System	2/1/2011	2/15/2011	11																	
1.3	Vacuum Nozzle and Motor	2/15/2011	3/1/2011	11																	
1.4	Power Supply	1/20/2011	2/1/2011	9																	
1.5	Battery Backup System	2/1/2011	2/8/2011	6																	
1.6	LCD Screen	2/22/2011	3/11/2011	14																	
1.7	Keypad	2/22/2011	3/8/2011	11																	
1.8	Alarm System	2/10/2011	2/18/2011	7																	
1.9	User Interface Configuration	2/22/2011	3/11/2011	14																	
1.10	Microprocessor Interface Setup	2/1/2011	2/22/2011	16																	
1.11	Board Etching	4/11/2011	4/25/2011	11																	
2	Programming	1/20/2011	3/11/2011	37																	
3	System Frame and Assembly	3/22/2011	4/8/2011	14																	
4	System Integration	3/22/2011	4/11/2011	15																	
5	System Testing	4/11/2011	5/2/2011	16																	
6	Finalize Prototype	4/18/2011	5/3/2011	12																	
7	Project Status	2/15/2011	3/10/2011	18																	
7.1	Milestone	3/10/2011	3/10/2011	1																	
7.2	Report	2/15/2011	3/8/2011	16																	
7.3	Presentation	3/8/2011	3/10/2011	3																	
8	User's Manual	4/12/2011	5/3/2011	16																	
9	Final Project	4/5/2011	5/5/2011	23																	
9.1	Milestone	5/5/2011	5/5/2011	1																	
9.2	Report	4/5/2011	5/3/2011	21																	
9.3	Presentation	5/3/2011	5/5/2011	3																	
10	Documentation	1/18/2011	5/5/2011	78																	
11	Project Management	1/18/2011	5/5/2011	78																	

Fall Network Diagram



Spring Network Diagram



Appendices

REQUIREMENTS SPECIFICATION

Background

Our team will analyze, build and test an automatic pill dispenser. This dispenser will be powered by a 120V AC, 60Hz power supply with a back-up battery to provide at least 12 hours of reserve power. The user will easily interface with the dispenser; in return it will dispense the correct amount of pills, on time, with the prompt of an alarm clock. The automatic pill dispenser combines microcontrollers with mechanical technologies, allowing for one user. The machine will operate with precision (explained further in test plan), ensuring that the correct prescription is dispensed at every instance of operation.

System Overview

According to the data released by PRIME Institute for Families USA, annual spending per elderly person for prescription drugs grew from \$559 in 1992 to \$1,205 in 2000, an increase of 116 percent. By 2010, annual per person spending on drugs for the elderly is projected to reach \$2,810 a year, an increase of 133 percent over spending in 2000

(<http://answers.google.com/answers/threadview/id/563761.html>). This data indicates that an ever-increasing number of elderly people are going to join the community of medicine dependent people, and significantly greater quantities of prescription medicine will be given to people daily. As a result, not only for the elderly people, but also for this group of people who are heavily dependent on medication, taking pills correctly and punctually will be a growing problem. There is a product designed to dispense medicine that has already been on the market; however, it costs \$1,200. Based on this situation, our group will research and develop an easily-manipulated device to dispense medicine at home, and reduce the manufacturing cost of the dispenser as much as possible.

Operational Description (Draft User's Manual)

Important Safeguards:

1. All users of the PEZ must read and understand this owner's manual before operating the PEZ.
2. The power cord should be plugged into a 120V AC electrical outlet only.
3. If the PEZ begins to malfunction during use, immediately unplug the cord. Do not use or attempt to repair the malfunctioning PEZ. Contact Team PEZ for further instructions.

Introduction:

To-Do: insert a brief description of the PEZ.

Before you use the PEZ for the first time:

1. Use inventory provided on first page of this manual to confirm all parts are present.
2. Assemble the PEZ and make sure the on/off switch is set to off. 3. Plug in the PEZ to power.

Set the clock:

1. Turn power switch to on position.
2. Details for this will be included once more research is done about the microprocessor.

Manual Entry of prescriptions or vitamins:

1. A step by step procedure will walk the user through a process of adding medication and alarms.

Cleaning and Maintenance:

A build up residue may hinder the performance of the pill counting mechanism. For best results, completely clean and dry all removable parts monthly or when needed. When cleaning your PEZ, please observe the following precautions:

1. Make sure the PEZ is off and unplugged. *All user data and dosage information will not be lost.*
2. NEVER IMMERSE THE CORD, PLUG OR PEZ IN WATER OR OTHER LIQUID.
3. Do not use metal cleaning pads or abrasive cleaners.

Requirements

1. Will handle up to 10 different kinds of pills ranging from 10 milligrams to 1 gram.
2. No more than four kinds will have the same mass, no more than four will have the same coating, and no more than three will have the same shape.
3. The alarm to take the dosage will sound within two seconds of the programmed time.
4. Should take no more than one minute to transport one pill from its holding chamber to the dispensing chamber.
5. Will alert the user when it is time to take a dose of medicine.
6. Prescription information (how many of each kind of pill to be taken at a specific time of day on certain days) can be entered manually through a user interface using a keypad and screen.
7. Will alert the user when a pill supply gets low (three days dosage left).
8. Will allow the user to access the pills by entering a secret PIN code. This applies when loading a supply of pills or retrieving a dose of pills.
9. Will be powered by a standard 120 V, 60 Hz, AC outlet.
10. Will have a battery back-up lasting at least 12 hours.
11. Should be a table-top device that can be carried by a typical person (definition of a typical person further explained in the test plan).

Design Deliverables

1. User Interfacing
2. Alarm Notifying Medication Times
3. User Recognition
4. Of Size Such that the Average Person can Lift it
5. User's Manual
6. List of Parts and Their Prices
7. Schematics
8. Automated Pill Dispenser Compatible with 1 user

Preliminary Test Plan

To test the pill dispensing functionality of the device, we will perform the following test (spanning 12 hours each run) three times:

- Plug Device into the wall for necessary power
- Load the hopper with 10 different types of Pills
- A user PIN will be assigned and then the pills can be placed in the machine.
- Different dosing schedules including: once a day, twice a day, and three times a day, including one or two pill doses using the LCD/Keypad interface will be tested.
- An alarm will sound alerting the user that it is time to pick up a prescription and the PIN will be entered.
- Once the PIN is entered, no less than one pill per minute (checked via stopwatch) will be dispensed until the dose has been completely dispensed.
- If there is only three days worth of a pill remaining, the user will be alerted by an alarm and an on screen message immediately following the dose retrieval that causes the amount to fall below the three day threshold.
- The system time will be checked against a digital clock/watch and will lose a maximum of two seconds during the test.

To test the backup battery system, the above test will be run twice running only on battery power for 12 hours with the following modifications:

- Pills and Dose Schedules will already be present in the machine

To test that the device can be carried by a typical person, the following test will be performed:

- Five people will be chosen at random and asked to carry the device from one end of a room to the other.